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A review of registrations for over-the-top dicamba products and liability for state governments for appropriating neighbors' right to exclude

Terence J. Centner

Professor of Practice, Agricultural Economics, University of Nebraska-Lincoln, Lincoln, NE 68583, USA

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ABSTRACT

Injuries inflicted by spray applications of dicamba herbicides on neighboring properties have raised questions about the validity of the dicamba registrations and the adequacy of protection accorded others. An evaluation of the documentation used by the Environmental Protection Agency in approving the 2020 dicamba registrations discloses a lack of evidence supporting issuance of the registrations. In the lawsuit challenging the 2020 registrations, the court may decide they need to be vacated. While over-the-top dicamba products for use on soybeans and cotton have been beneficial in controlling weeds, their volatility has caused major offsite injuries. Neighboring property owners have the right to exclude others from their properties, including the exclusion of spray drift and volatilization of pesticide particles. By approving dicamba registrations, states have enabled dicamba particles to invade offsite properties. The registrations obliterate neighbors' right to exclude others from their properties thereby constituting a taking of private property without just compensation for which state governments can incur liability.

1. Introduction

The injuries inflicted by spray applications of dicamba herbicides on neighboring properties have raised questions about the validity of the dicamba registrations and the adequacy of protection accorded others. After sales of genetically engineered soybean and cotton seeds tolerant of dicamba commenced in 2016, over-the-top (OTT) dicamba products were available to producers in 2017 (U.S. EPA, 2016). Four products became available: XtendiMax, FeXapan, Engenia, and Tavium. These OTT products could achieve better weed control since they could be applied on dicamba-tolerant soybean and cotton crops after the crops and weeds had started growing and only kill the weeds. The OTT dicamba products are diglycolamine or bis aminopropyl methylamine salts that have a lower volatility than earlier dimethylamine dicamba products (Ferreira et al., 2020; Minnesota Department of Agriculture, 2021; Mueller and Steckel, 2020). The earlier dicamba products had been used for decades for controlling weeds in corn, small grains, and pastures (Egan and Mortensen, 2012).

However, the use of OTT products in 2017 was accompanied by the colloidal suspension of dicamba particles in air being carried offsite causing significant injuries to other vegetation (U.S. EPA, 2017a). Two types of action were identified as contributing to the offsite injuries. First, physical spray drift at the time of application can be carried by the wind to downwind properties. The EPA noted that this is the dominant offsite exposure route (U.S. EPA, 2020c). Second, dicamba liquids or

solids on soil and plant surfaces can volatilize for up to 3 days after application of dicamba sprays (Weed Science Society of America, 2018). With temperature inversions, air currents can carry dicamba vapors offsite and damage vegetation (Bish et al., 2019). As noted by a senior scientist at the EPA in 2020, no volatility control measure has been identified that is certain to prevent offsite volatilization accompanying dicamba applications (U.S. EPA, 2020c). Several factors appear to increase the risk of volatilization injury including higher temperatures, larger leaf areas being sprayed, and a lower pH (Behrens and Lueschen, 1979; Bradley, 2019; Hartzler, 2017; Mueller and Steckel, 2019).

A particular problem is that non-dicamba-tolerant soybeans are very susceptible to injury from dicamba (Griffin et al., 2013; Osipitan et al., 2019). Due to the proximity of dicamba-tolerant and non-dicamba-tolerant soybeans, OTT drift and volatilization injured an estimated 3.6 million acres of non-dicamba-tolerant soybeans in 2017 (Bradley, 2017). Other crops and vegetation were also adversely affected. The Environmental Protection Agency (EPA) and product registrants responded by adding restrictions in the products' labels (Table 1). For the 2018 crop year, OTT products were reclassified as restricted use pesticides, producers were required to maintain specific records, products could only be applied under certain wind speeds, and applications needed to be between sunrise and sunset (U.S. EPA, 2018a).

The labeling restrictions applying in 2018 failed to end unacceptable offsite injuries (Waltz, 2018; Payne, 2018). Yet, the EPA proceeded to issue amended conditional registrations for three OTT herbicides in late 2018 so the products could be used in 2019 and 2020 (U.S. EPA, 2018b). Under revised registrations, only certified applicators could apply OTT products in 2019 and 2020, and a few more limitations were

OTT, over-the-top; EPA, Environmental Protection Agency.

E-mail address: tcentner2@unl.edu

Table 1
Changes in label requirements from 2017 to 2021.

Requirement	2017 ^a	2018 ^b	2019 ^c	2020 ^c	2021 ^d
Spray drift buffer	110" downwind	110" downwind	110" downwind	110" downwind	240" downwind
Wind limitation for sensitive plants	Yes	Yes	Yes	Yes	Yes
Volatility buffer for endangered species	None	None	57' all sides	57' all sides	57' all sides & sensitive plant prohibition
Wind speed limitation	Up to 15 mph	3–10 mph	3–10 mph	3–10 mph	3–10 mph
Limitation on time of day	None	Sunrise to sunset	1 h after sunrise & 2 h before sunset	1 h after sunrise & 2 h before sunset	1 h after sunrise & 2 h before sunset
Applicator recordkeeping	None	Within 14 days	Within 72 h	Within 72 h	Within 72 h
Labeled as restricted use	No	Yes	Yes	Yes	Yes
Only certified applicators	No	No-under direction	Yes	Yes	Yes
Applicator dicamba training	None	Yes	Additional	Additional	Additional and state requirements
Limits on use after planting or calendar date	None	None	Yes: soybeans 45 days; cotton 60 days	Yes: soybeans 45 days; cotton 60 days	Soybeans – June 30; Cotton – July 30
State-imposed end date	None	AR, MI, MN ^d	AR, KY, IL, IN, MI, MN, ND, SD ^d	AR, IL, IN, MN, ND, SD ^d	AR, IL, IN ^d
Equipment cleanout	Cleanout sprayer	Cleanout sprayer	Cleanout entire system	Cleanout entire system	Cleanout entire system
Volatility reduction agent	None	None	None	None	Required

^a U.S. EPA (2016).

^b U.S. EPA (2018a, 2018c).

^c U.S. EPA (2019).

^d U.S. EPA (2020d),^eBradley (2019) and other sources.

added (Table 1). However, the limitations failed to curtail offsite injuries (Association of American Pesticide Control Officials, 2020). States also reported that the OTT products were imposing a financial burden on regulatory agencies that was unsustainable (Cofer, 2018).

A lawsuit by the National Family Farm Coalition led to a judicial decision vacating three 2018 registrations (*National Family Farm Coalition vs. EPA*, 2020), and the 2018 registrations were canceled by the EPA (U.S. EPA, 2020a). However, despite this ruling, the EPA issued new registrations in 2020 enabling OTT products to be used during 2021–2025 crop years (U.S. EPA, 2020b). As expected, these registrations were challenged for failing to comply with federal pesticide law (*American Soybean Association vs. Wheeler*, 2020). This paper examines the evidence considered by the EPA and the agency's conclusion that the OTT products qualified for registration in 2020. The paper's review of the causes of offsite injuries, shortcomings of studies and field tests evaluating dicamba volatilization, and limitations of data used to justify the registrations suggest that the EPA and state regulatory agencies failed to adhere to the registration requirements of federal pesticide law.

While the legality of the 2020 registrations is important, equally as troubling are the unauthorized invasions of dicamba particles on neighboring properties that accompany applications of OTT products. Owners of property have the right to exclude others from their properties. Applications of dicamba accompanied by drift and volatilization to offsite properties violate this right to exclude. In 2021, the U.S. Supreme Court issued a new interpretation on the right to exclude in the *Cedar Point Nursery vs. Hassid* (2021) lawsuit. The judicial decision expands the protection afforded property rights under the federal Constitution's "Takings Clause" to include the government-authorized invasions of property. Under the rationale of the *Cedar Point Nursery* ruling, state governments can bear responsibility adopting regulations that obliterate neighbors' right to exclude by granting rights to invade others' property.

2. Evaluating the 2020 OTT registrations

An evaluation of the 2020 OTT product registrations posits compelling arguments for concluding that the registrations fail to comply with federal law. In addition, with the EPA's admission that the 2018 registrations were issued after "senior-level changes to or omissions from scientific documents" (U.S. EPA, 2021), questions are raised whether similar improprieties accompanied the 2020 registrations.

2.1. Extent of injuries and causes

State regulatory officials, the EPA, and weed scientists were aware of the injuries inflicted by dicamba applications by the fall of 2017 (U.S. EPA, 2017b). Applications of OTT products had caused an "unprecedented triple digit increase" in the number of offsite injury complaints (Indiana State Chemist and Seed Commissioner, 2019). Despite new requirements imposed by the products' labels in 2018 and 2019, excessive numbers of offsite injuries continued to be reported to state regulators. The magnitude of the offsite injuries led the Association of American Pesticide Control Officials to suggest in 2020 that post-emergent soybean applications should be prohibited (Reed, 2020).

In approving the 2018 and 2020 registrations, regulatory officials declined to fully consider the causes of the injuries to offsite vegetation (Table 2). While some of the causes were addressed by subsequent label changes, others were ignored. Revised labels addressed wind, temperature, buffers, nozzles, and equipment clean-out. Revised labels failed to address injuries that would occur due sudden changes in weather causing volatilization, short time frames for applying dicamba sprays, and applicators not adhering to label directions. A survey from Illinois disclosed that 30% of commercial applicators had not been able to always follow the label requirements in 2018 (Illinois Fertilizer and Chemical Association, 2018).

2.2. Studies and field tests

In approving registrations of OTT products, the EPA examined data from studies and field tests that examined possible offsite injury from exposure to dicamba from drift and volatilization (Table 3). For the initial 2016 registrations, exposure was estimated from a single application, volatilization was only considered to occur within 24 h, and it was assumed that subsequent exposures would not contribute to the toxic effects (U.S. EPA, 2016, pp. 12, 22). The assumptions on volatilization and subsequent exposures are now known to be incorrect. The OTT products may remain volatile for 3 days (Weed Science Society of America, 2018), and some producers use two applications enabling multiple exposures (Chism et al., 2020). Moreover, scientists conducting some of the studies were precluded from conducting testing on volatilization (Knox, 2019).

Additional studies provided data that was interpreted for issuing new registrations for the 2021–2025 production years (Table 3). The registrants submitted three field studies conducted in 2019 for which test

Table 2
Causes of injuries from dicamba applications and regulatory label responses.

Factor ^a	Problem	Year addressed ^{b,c}
Too windy	Drift to non-tolerant vegetation	2018 - reduced speed
Inadequate buffer zones	Drift to non-tolerant vegetation	Not addressed for volatilization
Temperature inversion	Volatilization increases at beginning and end of days	2018, strengthened in 2019
Nozzles not calibrated correctly	Particles carried as drift	2018
Clean-out procedures	Residual dicamba contaminated subsequent field	2018, strengthened in 2019
Weather changed during application	Wind or temperature increased leading to drift injuries	Not addressed
Too short of time frame	Sprayed off-label	Not addressed
Use after non-DT soybeans are susceptible to injury	Increased likelihood of injury	Cutoff dates set in 2019 did not address growth stages
Volatilization	Occurs after spraying so not controlled by wind speed	Insufficient small omnidirectional buffer
Untrained applicators	Improper applications	2018 - classified as restricted use; 2019 - only certified applicators
Not adhering to directions	Causing drift or volatilization	Not addressed

^a Illinois Fertilizer and Chemical Association (2018).

^b U.S. EPA (2018c).

^c U.S. EPA (2019).

Table 3
Studies and field tests for justifying the 2020 dicamba registrations^a.

Identification	Limitation	Pages
Greenhouse studies	Not applicable to large fields	182–188
2015 to 2018 registrant studies for XtendiMax	Significant offsite injuries in 2017–2020 meant the studies failed to predict injuries so are unreliable	208–213
2016 registrant studies for Engenia	Significant offsite injuries in 2017–2020 meant the studies failed to predict injuries so are unreliable	228
2017 & 2018 university studies	Significant offsite injuries in 2018–2020 meant the studies failed to predict injuries so are unreliable	213–230
2019 studies	Many of the fields were smaller than fields where OTT products are applied	230–237
	Applications of OTT products followed by rain events that preclude volatilization results	238–241
	All studies involved small fields and considered only a single application even though some applicators apply a second spray	241–265
	Significant offsite injuries in 2020 meant the earlier studies failed to predict injuries so are unreliable	182–265

^a U.S. EPA (2020c).

plots of 19–24 acres were planted to dicamba-tolerant soybeans surrounded by non-dicamba-tolerant soybeans in Illinois, Mississippi, and Missouri (U.S. EPA, 2020c, pp. 230–23). For the Illinois study, the single application of dicamba was applied in August and two inches of rain fell during the five days after the application. The Mississippi study involved one application of dicamba followed by a heavy thunderstorm between 24 and 48 h of the study. Given that volatilization can occur 3 days after application and rainfall events reduce volatility, these field tests would not accurately measure volatilization injuries. The EPA excluded the Missouri study due to delayed planting.

The EPA also relied on a set of studies conducted by five universities, each study having a field size of less than ten acres and some were less than one acre (U.S. EPA, 2020c, pp. 238–241). Because these small fields had less quantities of dicamba applied than occur in most production areas, the studies could not prove whether the volatility of the tested products would adversely affect offsite vegetation.

A third set of several registrant-sponsored studies included five studies that the EPA determined to be inappropriate for evaluating the protectiveness of in-field application setbacks (U.S. EPA, 2020c, pp. 241–261). The only studies that might have meaningful results had small field sizes that were not representative of normal growing conditions (U.S. EPA, 2020c, pp. 241–261). As summarized by experts in 2018, studies of small fields are inappropriate for calculating buffer distances because they involve fewer airborne particles than would occur with larger field sizes used in the production of most soybeans (U.S. EPA, 2020c; Weed Science Society of America, 2018). Thus, all the studies submitted for the new registrations in 2020 were compromised by various factors including only involving a single spray application, small fields, and rain events eliminating volatilization. The EPA had no compelling data to justify its selection of buffer distances to limit volatilization injuries.

The reported offsite injuries from dicamba applications during the 2017–2020 growing seasons were proof that the EPA's conclusions from studies and tests conducted prior to 2020 were wrong. Because the stud-

ies and tests led to the erroneous conclusion that applications of OTT products would not cause offsite injuries, they do not offer reliable support for the 2020 registrations.

2.3. Other data limitations

The EPA's conclusion that injuries from volatilization would not be a problem was further compromised by the model selected to establish the likelihood of offsite injury (U.S. EPA, 2020c). The model employed studies that used a volatility reduction agent to eliminate offsite injuries (see Table 4). However, deficiencies in the studies mean they do not support the EPA's conclusion that volatilization would no longer cause offsite injuries.

A major limitation is that the studies of volatility reduction agents did not use registered dicamba formulations. In the absence of the same formulations, it is unclear that the results are meaningful. Second, in evaluating the visual signs of injury tests, the EPA did not consider soybean variety and field and agronomic factors. Thus, the data may not be predictive of potential injuries to non-dicamba-tolerant soybeans. In fact, the EPA admitted that the predictive offsite toxicity may not provide an exact accounting (U.S. EPA, 2020c, p. 10). Third, to respond to volatility injuries, the EPA considered endangered species for the establishment of its omnidirectional volatility buffer thereby ignoring injury to non-endangered species (U.S. EPA, 2020b). Since not many counties growing dicamba-tolerant soybeans and cotton have endangered species, this means that volatility buffers were never evaluated for areas where most crops are grown.

Another limitation is that some of the volatility studies were conducted in laboratories and greenhouses, and none considered applications of dicamba to large acreages. Greenhouse studies typically measure plant survival and height under experimental conditions for important data. However, the results from a greenhouse study cannot be easily translated to what transpires in actual field conditions due to climatic variables and differences in the quantities of released spray from ap-

Table 4
Limitations of studies providing data evaluated by the U.S. EPA in justifying the 2020 dicamba registrations^a.

Item	Limitation	Page
Volatility reduction agents	Not used with registered dicamba formulations	189
Visual signs of injury testing	Not predictive of yield loss	10
Potential injuries to non-DT soybeans	Likely dependent upon soybean variety and field and agronomic factors	11
Predictive offsite toxicity	Exact impact unknown	189
Volatility studies	Some conducted in laboratories and greenhouses that fail to account for weather conditions	14 & 189
Label cut-off dates for use	Not appropriate for all 34 states and less restrictive than some state regulations	14
Volatility buffers	Adopted the same distance as used in the 2018 registrations that led to unacceptable off-site injuries	4
Volatility results	Injuries expected from 11 percent of applications	324

^a U.S. EPA (2020c).

plications to large and multiple fields (Sall et al., 2020). Greenhouse studies also do not capture measures of crop yields (U.S. EPA, 2020c).

For the 2020 registrations, the EPA used the same buffer distances for volatility that were established in the 2018 registrations despite widespread offsite injuries occurring during the 2019–2020 crop years. Thus, the EPA did not have sufficient scientific evidence for selecting a volatilization buffer and did not effectively address the volatilization issue. Unless the new volatility reduction agents markedly reduce volatility, the omnidirectional federal buffer is insufficient to preclude injury to neighboring properties (Baldwin, 2018; University of Arkansas System, 2021). To protect offsite properties in Arkansas, the state has adopted buffers of $\frac{1}{4}$ mile, $\frac{1}{2}$ mile, and one mile depending on the location of the applications (Butts et al., 2021).

Perhaps the most egregious information from the studies was that the failure rate of preventing offsite injuries was 22% (EPA, 2020c, p. 324). The EPA acknowledged that injuries could be expected from 11% of OTT applications, yet proceeded to issue the registrations (EPA, 2020c, p. 325). Federal law does not condone such injuries. Without protection against offsite volatilization injuries, the products should not qualify for registration under federal law.

3. Compensating property owners suffering injuries

The injuries that dicamba spray applications are placing on offsite property owners raises the question whether state approvals of pesticide registrations constitute unconstitutional takings. The Takings Clause of the Fifth Amendment to the U.S. Constitution provides that private property shall not be taken for public use without just compensation. If a government wants the property of another, it can use an eminent domain proceeding to purchase the property (Schwartz, 2015). Whenever a government declines to use eminent domain yet invades private property, an inverse condemnation procedure is available to force the government to pay for the interest taken (Echeverria, 2020). In a similar manner, if a government takes an easement, there may be a taking.

In the *Cedar Point Nursery vs. Hassid* (2021) lawsuit, the U.S. Supreme Court evaluated a California regulation creating an easement that gave union organizers a “right to take access” to agricultural employers’ properties to solicit support for unionization (California Code of Regulations, 2020). One of the key rights of property ownership is the right to exclude others from one’s private property (Glazer, 2008). The *Cedar Point Nursery* Court recognized that excluding others from private property is a treasured right. Ownership of property entails dominion that includes the fundamental element of being able to prevent invasions by others. After evaluating the facts, the Court found that an easement created by a state regulation allowing temporary entry on private property constituted a *per se* physical taking of private property. Entry by union organizers authorized by the regulation appropriated a right of access to the growers’ private property.

While the property right to exclude pesticide particles was not considered by the Supreme Court in the *Cedar Point Nursery* lawsuit, the court’s analysis of a governmentally-authorized invasion of property is similar to invasions of pesticides to offsite properties. Pesticide drift and volatilization from OTT products damaging offsite vegetation of-

fends property ownership. Registrations of dicamba products granted dicamba applicators the ability to apply spray applications accompanied by invasions of herbicide particles onto private property. By approving OTT product registrations, states granted applicators an easement under which dicamba drift and volatilization physically invade offsite properties. The governmentally-authorized physical invasions constitute *per se* takings and governments issuing registrations can incur liability for the injuries.

4. Concluding comments

Since 2017, it has been known that OTT dicamba applications are accompanied by spray drift and volatilization that invade offsite properties causing injury. By approving dicamba registrations, state governments have enabled applicators to use products even though applications result in damages to neighboring properties. These damages create an unfair situation under which neighboring property owners lack an effective recourse. Under U.S. law, property owners have the right to exclude others from their properties. The entry of dicamba particles violates this property right.

Agricultural interest groups and people living in rural communities are normally keen on protecting property rights. Rather, surprisingly, few in the agricultural community have voiced support or offered assistance to protect the property rights of neighbors injured by offsite dicamba applications. While the production of food is important, it should not be interpreted as a license for engaging in practices that harm others. Residents in rural communities have a right to feel secure on their properties that includes not being subjected to injuries from neighboring spray applications. The uncompensated injuries to crops and vegetation suffered by neighbors from dicamba spray applications reveal governments forgoing responsibilities in protecting property rights.

In the *Cedar Point Nursery vs. Hassid* ruling by the Supreme Court, it was found that a governmental appropriation of a right to exclude was a taking of private property that needed to be compensated. The state registrations of OTT products appropriate neighbors’ right to exclude others from their properties. Since this property right has been taken, state governments should pay for it. Judicial tribunals will be asked to determine how this new interpretation of the Takings Clause applies to other governmental laws and regulations.

Until a court rules whether state governments can incur liability for their issuance of registrations for of OTT products, states might contemplate their options. First, state governments can hope that the *Cedar Point Nursery* rationale does not apply to pesticide registrations. The distinction is that the *Cedar Point Nursery* decision involved entries by people rather than pesticide particles. Second, a federal court may vacate the 2020 registrations, as occurred with the 2018 registrations. This would end OTT product sales until new registrations were issued. Soybean and cotton producers would need to find an alternative method to control weeds. Third, state governments might decide to cancel registrations thereby obviating the possibility of future *per se* takings from offsite invasions. Given the economic importance of OTT products, this is unlikely until there is a judicial decision foisting liability on a state government.

Another option is for a state to allow dicamba to be used pursuant to a compensation program under which injured property owners are compensated (Centner, 2021). Dicamba users would pay a fee when purchasing dicamba products that would be deposited in a compensation program fund. Monies in the fund would then be used to pay injured property owners for damages resulting from dicamba spray applications. A compensation program would thereby enable producers to use OTT products and provide compensation to injured property owners for violations of the right to exclude. Under a program direct confrontation by neighbors would be avoided and payments would reduce the tension and animosity that currently exist in many areas where dicamba is being used. Governments have responsibilities to all their citizens. To uphold the sanctity of private property rights, state governments should acknowledge their obligations to persons suffering injuries from dicamba spray applications.

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Declarations of Competing Interest

None

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